REMARKS

Summary

Applicants gratefully acknowledge the Examiner's time by telephone on November 20, 2006 to discuss the rejections of the claims.

Claims 30-31, 33-43, 46-53, 78-80, 82, 101-103, and 105-140 are pending. Claims 30 and 101 are amended for consistency with the language in claim 102, as supported by the specification in paragraph [0022]. Claims 32 and 104 have been canceled. Claims 72-77 and 81 have been withdrawn from consideration. Claims 132-140 are new and find support in the specification at least in paragraphs [0065]-[0072] and [0100], in Figs. 4,6, and 9, and in the original claims. No new matter has been added.

Rejections Under 35 U.S.C. § 103

The Examiner asserted that claims 30-53, 78-80, and 101-110, and 112-119 are unpatentable over Lee et al. ("Lee," EP 1246238) in view of Malik et al. (6,881,644) under 35 U.S.C. §103(a). Applicants respectfully disagree.

Claims 31, 33-53 and 78-80 depend from claim 30 and therefore include all of the limitations of claim 30. Likewise, claims 103, 105-110 and 112-119 depend from claim 102 and thus contain all of the limitations of claim 102. Claims 32 and 104 have been canceled to avoid redundancy with claims 30 and 102.

Claims 30, 101 and 102

Claims 30, 101 and 102 recite a method of bonding two structures wherein at least one of the bonding layers comprises an amorphous material. Annealing is employed to bond the structures together and entails crystallizing at least a portion of the amorphous material into a polycrystalline material.

The Examiner asserted that the abstract of Malik discloses annealing under conditions sufficient for a bonding layer to crystallize from an amorphous material into a polycrystalline material. Applicants submit that there is no such no teaching or suggestion in the abstract of Malik. In fact, *not one* of the words "anneal," "bond," "crystallize," "amorphous," or "polycrystalline" even appears in the abstract, which

describes a smoothing method for cleaved films. The Examiner is requested to specifically point out which portion of the abstract discloses "annealing of the combined structure occurred under conditions sufficient for the bonding layers crystallizes *[sic]* into a polycrystalline material" as alleged in the Office action.

The Examiner also asserted that col. 12, lines 40-50 of Malik disclose annealing "so as to provide the bonding the *[sic]* of the structure with crystallized material." Applicants point out that the claim recites "*annealing* the combined structure under conditions sufficient for the bonding layers *to bond* the first and second structures together, wherein the annealing comprises *crystallization of at least a portion of the amorphous material into a polycrystalline material*." The portion of Malik cited by the Examiner describes the formation of an oxidized film by heat treatment in an oxygen atmosphere. (col. 12, lines 44-46) There is no discussion of bonding in this section, since Malik's oxidation process *is not a bonding process*. Malik uses oxidation to form an insulating layer (SiO_2) on a silicon substrate *before* the substrate is bonded to another substrate (col. 11, lines 30-36 and lines 51-60). No bonding of first and second structures occurs during oxidation. There is also no disclosure in Malik of crystallizing an amorphous material into a polycrystalline material during annealing. At best there is reference to oxidizing "only the surface of the pore inner wall such that the monocrystalline property remains inside the pore wall of the porous layer." (col. 12, lines 40-42) Retaining a *monocrystalline* structure of a portion of a single-crystal porous layer during heat treatment does not constitute *crystallization* of an *amorphous* material into a *polycrystalline* material during an annealing process, as recited by the claims. Lee also does not disclose this limitation of the claims, as the Examiner acknowledged in the Office action.

Since the references cited by the Examiner, either alone or in combination, do not teach or suggest each and every element of the claims, a *prima facie* case of obviousness has not been established with respect to claims 30, 101 and 102, and any claims depending therefrom.

In addition, Applicants submit that some of the claims are independently patentable over Lee in view of Malik.

Claims 123 and 129

Claims 123 and 129 recite crystallizing substantially all of the amorphous material to a polycrystalline material in the annealing process. The Examiner incorrectly asserted that col. 12, lines 1-15 of Malik disclose this limitation of the claims. Per the preceding arguments, there is in fact no teaching or suggestion of crystallizing an amorphous material to a polycrystalline material by annealing in Malik.

Claims 33-35 and 105-107

Claims 33 and 105 recite annealing the combined structure at a temperature of between about 300°C and 500°C for a time sufficient to form a (Ga,As) layer that is substantially entirely polycrystalline. There is no disclosure anywhere in Lee of using arsenic (As) as one of the materials (11, 13) for the multistacked layers (15,17), much less the formation of a (Ga,As) material from the layers. Lee also does not disclose the claimed annealing temperatures. The Examiner refers to col. 12, lines 40-50 of Malik in the rejection. However, there is no discussion whatsoever in these sections of annealing at the claimed temperatures to form a polycrystalline (Ga,As) material. Instead, Malik describes oxidizing a porous silicon layer at temperatures of 200°C to 700°C to produce an oxidized film. The claimed bonding layer material (Ga,As) is not mentioned, much less the formation of a substantially entirely polycrystalline (Ga,As) material by annealing.

Claims 34 and 106 recite annealing the combined structure at a temperature of between about 500°C and 700°C for a time sufficient to form a (Ga,P) layer that is substantially entirely polycrystalline. There is no disclosure anywhere in Lee of using phosphorus (P) as one of the materials (11, 13) for the multistacked layers (15,17), much less the formation of a (Ga,P) material from the layers. Lee also does not disclose the claimed annealing temperatures. Once again, the Examiner refers to col. 12, lines 40-50 of Malik in the rejection, in which the oxidation of silicon to SiO_2 is described. There is no disclosure in this section, or anywhere else in Malik, of the claimed bonding layer (Ga,P) material, much less forming a polycrystalline (Ga,P) material by annealing at the claimed temperatures.

Claims 35 and 107 recite annealing the combined structure at a temperature of between about 700°C and 900°C for a time sufficient to form a (Ga,N) layer that is

substantially entirely polycrystalline. There is no disclosure anywhere in Lee of the formation of a (Ga,N) material from the layers. Lee also does not disclose the claimed annealing temperatures. The Examiner points to col. 12, lines 1-15 of Malik in the rejection, in which heat treating silicon and/or SiO_2 substrates after bonding is described. (col. 11, lines 30-67, col. 12, lines 1-15) However, there is no disclosure in the section of Malik cited by the Examiner, or anywhere else in Malik, of the claimed bonding layer material (Ga,N) or of annealing at the claimed temperatures to form a polycrystalline (Ga,N) material, as recited by the claims.

Claims 31, 103, 121, and 127

Claims 31 and 103 recite applying a pressure substantially uniformly to the combined structure during annealing. The Examiner erroneously asserted that Lee discloses this limitation in Fig. 4B. In fact, Lee teaches that the compound bond layer may be formed "without having to apply pressure to achieve the bonding." (page 3, lines 30-31) Furthermore, the pressure disclosed in Lee that occurs incidentally due to gravity on the mass of the upper substrate (page 6, lines 35-38) does not constitute the *application* of pressure to a *combined structure* that includes both first and second structures (substrates) and the bonding layers deposited thereon, as recited by the present claims. Claims 121 and 127 further recite that the pressure applied to the combined structure is an *external* pressure. As discussed above, no such external pressure is disclosed in Lee.

Claims 39-41, 43, 109-111, 124-125, and 130-131

Claims 39 and 109 recite annealing the combined structure under conditions that are sufficient to form bonds strong enough to survive subsequent processing at temperatures higher than those used during bonding. The Examiner alleges that the limitations of these claims are disclosed in the abstract of Lee. In fact, there is no discussion in the abstract of Lee about subsequent processing of the bonded structure at higher temperatures than those used during bonding.

Claims 40 and 110 recite that a bonding interface produced by the annealing is substantially optically transparent to light emitted by the combined structure. The Examiner asserted that the abstract of Lee discloses this limitation. To the contrary,

there is no teaching or suggestion in the abstract, or anywhere else in Lee, that the bonding interface is optically transparent.

Claim 41 recites that a bonding interface produced by the annealing is strong enough to be substantially *unaffected* by processing of the combined structure. In the prior Office Action, the Examiner incorrectly stated that the abstract of Lee discloses this limitation. In fact, the abstract of Lee teaches that processing of the combined structure can *dissolve* the bond. A bonding interface that can be dissolved is not substantially unaffected by processing, as required by claim 41.

Claims 43 and 111 recite that the deposition deposits at least one of low temperature grown (Ga,As), (Ga,P), and (Ga,N) on at least one of the first and second structures. Claims 124 and 130 recite that at least one bonding layer may comprise a ternary or quaterary compound, and claims 125 and 131 recite that the compounds may be selected from (In,Ga,As), (In,Ga,P) and (In,Ga,As,P). The Examiner erroneously asserted that these claim limitations are disclosed in Malik at col. 14, lines 53-67. In this section Malik teaches that it is not the bonding layer, but the *substrate* that can be made of Group III/V materials, such as gallium arsenide and gallium nitride. There is no discussion whatsoever of the deposition of low temperature grown (Ga,As), (Ga,P), and (Ga,N) *bonding layers* on a substrate. Nor is there any disclosure of ternary or quaternary compound bonding layers, much less the specific compounds recited in claims 125 and 131.

Claim 49

Claim 49 recites that the bonding layer comprises a "compound" semiconductor. Applicants respectfully disagree with the Examiner's assertion that *compound* semiconductor bonding layers are disclosed in Lee on page 5, line 50. This line of Lee makes reference to an "elemental compound" that may be used as the first and second materials 11, 13. Applicants submit that Lee's use of the word "compound" juxtaposed with "elemental" is technically inaccurate and does not represent the disclosure of bonding layers on first and second structures comprising a "compound" semiconductor, as recited by claims 101 and 102. Upon reading the specification, one of ordinary skill in the art would recognize that Lee's "elemental compound" may be an "element" or an "elemental material," but is not a "compound" by any proper definition. As is well known

in the art, a "compound" includes at least two elements bound together in definite proportions. Lee discloses "elemental selenium" and "elemental indium" as exemplary "elemental compounds" in paragraph [0060]. One of ordinary skill in the art would readily recognize that neither selenium nor indium is a compound. Only *after* the elemental bonding layers of Lee have undergone the selenidation reaction to form the bonded structure is a compound semiconductor (e.g., In_xSe_y) formed in Lee. Applicants further point out that the addition of tellurium to a selenium layer, as disclosed in Lee, yields an alloy of the two elements and does not constitute the formation of a *compound* semiconductor bonding layer. Applicants refer the Examiner to U.S. Patent 3,723,105, "Process for Preparing Selenium-Tellurium Alloys," which describes the vapor deposition of selenium-tellurium alloy films. In summary, Lee does not disclose compound semiconductor bonding layers, as recited in claim 49.

Claims 50, 53, and 119

Claim 50 recites doping the bonding layer with silicon. The Examiner alleges that this limitation is disclosed in col. 8, lines 1-15 of Malik. In this section, Malik discloses silicon films. The disclosure of films composed of silicon does not constitute *doping* with silicon. As one of ordinary skill in the art would know, doping with silicon entails deliberately adding a small amount of silicon to another previously formed semiconductor in order to modify the electronic properties of the semiconductor. Doping of the claimed bonding layers with silicon is neither taught nor suggested by Malik.

Claims 53 and 119 recite a bonding layer deposited by molecular beam epitaxy at a temperature of at most about 100°C. The Examiner alleged in the prior Office Action that Lee discloses this limitation on page 5, at line 50. In fact, Lee does not teach this deposition technique on page 5 or anywhere else in the specification.

Claims 80 and 82

Claim 80 recites that the first and second structures comprise a pseudomorphic structure, which is not disclosed anywhere in Lee or Malik.

Claim 82 recites that the bonding layer is *devoid* of polymers, ceramics, and metals. Since Lee discloses the use of metals as exemplary materials for the bonding

layer (*e.g.*, aluminum (Al), indium (In)), and Malik teaches the use of SiO_2, the references clearly do not teach or suggest the limitations of claim 82.

In view of the above remarks, Applicants respectfully request that the Examiner withdraw the rejection of claims 30-53, 78-80, 101-110, 112-119 under 35 U.S.C. § 103(a).

Conclusions

Applicants respectfully submit that all of the pending claims are in condition for allowance. If for any reason the Examiner is unable to allow the application in the next Office action and believes that a telephone interview would be helpful to resolve any remaining issues, the Examiner is invited to contact the undersigned.

Respectfully submitted,

Mindy N. Rittner

Mindy N. Rittner, Ph.D.
Registration No. 57,803
Agent for Applicants

BRINKS HOFER GILSON & LIONE
P.O. BOX 10395
CHICAGO, ILLINOIS 60610
(312) 321-4200